PB-218 188

AN INDUSTRIAL WASTE GUIDE TO THE MEAT INDUSTRY

Public Health Service
Washington, D.C.

1965

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

PB 218 188

an Industrial Waste Guide to the

Meat Industry

Prepared by the
Committee on Sanitation and Waste Treatment
of the American Meat Institute
in cooperation with the National Technical
Task Committee on Industrial Wastes

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
Division of Water Supply and Pollution Control
Washington, D.C. 20201

Other publications in the Industrial Waste Guide Series

PHS Pub. No. 991: Poultry Processing Industry (in press)
PHS Pub. No. 952: Fruit Processing Industry
PHS Pub. No. 756: Potato Chip Industry
PHS Pub. No. 691: Cane Sugar Industry
PHS Pub. No. 677: Cotton Textile Industry
PHS Pub. No. 509: Commercial Laundering Industry
PHS Pub. No. 438: Wool Processing Industry
PHS Pub. No. 298: Milk Processing Industry

Public Health Service Publication No. 386
Revised 1965

Dedication

This guide is dedicated to the memory of A. Stanford Johnson, general project engineer, Oscar Mayer & Co., who devoted many hours to its preparation.

Mr. Johnson was an instructor and research fellow in the Civil Engineering Department, University of Minnesota prior to his association with Oscar Mayer & Co. In 1956, while working toward his M.S.C.E. at Minnesota, he was a joint winner of the Harrison Prescott Eddy Medal for noteworthy research. The research involved study of various aspects of the anaerobic contact process for treatment of meat plant wastes. This work led to the adoption of this method of treatment first at Albert Lea, Minn., and later at Austin, Minn., and Momence, Ill.

Mr. Johnson was active in the National Technical Task Committee on Industrial Wastes; the American Meat Institute Sanitation and Waste Treatment Committee; American Waterworks Association; Central States Water Pollution Control Association; Water Pollution Control Federation, and the Institute of Sanitation Management.

A. Stanford Johnson was an excellent engineer. He understood the relationship of scientific investigation to engineering and as the result of this understanding his company and the meat industry made significant progress in the field of waste treatment.

Preface

In the meat industry, as in many others, control and disposal of wastes is a major concern of many plants. Optimum utilization and reduction of wastes is essential for the most economical production in small as well as large plants. Wastes which cannot be eliminated must be disposed of in suitable manner. Protecting the Nation's limited water resources for maximum use is mutually beneficial to industry, other special groups, individual citizens, and the Nation as a whole. In recognition of this, industries are paying increasing attention to the disposal of their wastes in a manner which will not impair the utility of stream waters for other beneficial uses.

The original Guide was prepared by the U.S. Public Health Service and published in supplement D of the report entitled "Ohio River Pollution Control" in 1943.

In 1954 the Committee on Meat Packing Plant Waste Disposal of the American Meat Institute suggested some changes which were incorporated in a revised issue of the Guide to bring it up to date. Further revisions of the Guide were prepared by the Committee on Sanitation and Waste Treatment in 1964 to include information on primary treatment, the anaerobic contact process and anaerobic-aerobic ponds. These changes were submitted to the Public Health Service through the meat industry representative on the National Technical Task Committee on Industrial Wastes and are incorporated herein.

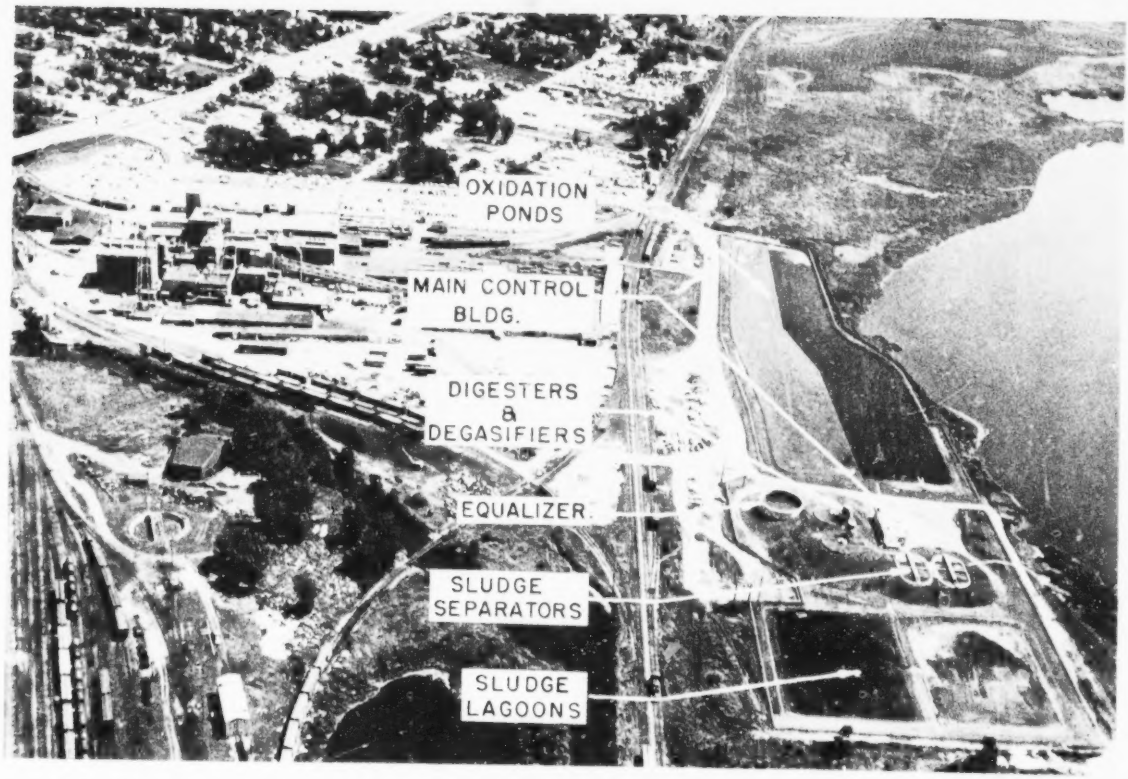
The National Technical Task Committee is composed of representatives from the Nation's leading industries concerned with solving difficult industrial waste problems. The objective of the organization is to perform technical tasks pertaining to industrial wastes in cooperation with the Public Health Service and all others concerned with improving the quality of our water resources. The preparation of this revision was one of the tasks assumed by the meat industry in carrying out this objective.

Preceding page blank

CONTENTS

	Page
INTRODUCTION	1
DESCRIPTION OF PROCESS	1
RAW MATERIALS AND PRODUCTS	2
ORIGIN OF WASTEWATER	2
Slaughterhouses	2
Packing Plants	3
Stockyards	4
Processing Plants	4
COMBINED WASTEWATER FLOW AND CHARACTERISTICS	5
POLLUTION EFFECTS	6
REMEDIAL MEASURES	6
Plant Practices	6
Treatment	8
Primary	8
Secondary	8
Trickling Filters	8
Irrigation	8
Anaerobic Contact	9
Stabilization Ponds	10
BIBLIOGRAPHY	13

Preceding page blank



Full scale anaerobic contact waste treatment plant, Wilson & Co., Inc., Albert Lea, Minnesota, U.S.A.

Introduction

This publication represents the efforts of waste technologists of the meat industry and others to develop a concise practical Guide for operating and design personnel. Reduction of wastes at their source is the initial objective of control measures. Appreciable reduction of waste can be accomplished through waste prevention measures carried out within the meat processing plant.

The section on treatment is not intended to be a comprehensive discussion of meat processing waste treatment. Sufficient information on waste treatment is included to suggest possible methods of solution to stream pollution problems which cannot be eliminated or adequately corrected by waste prevention procedures. Some performance data are presented on the more usual as well as the more recently developed meat processing waste treatment processes. This section will also serve to emphasize to meat plant supervisory personnel the value of waste saving methods in reducing total waste treatment costs.

The wastes from stockyards, slaughterhouses, and packinghouses are similar chemically to domestic sewage but are considerably more concentrated. The principal deleterious effect of these wastes on streams and other bodies of water is their deoxygenating effect.

Stockyard wastes contain animal excreta, and the amount and strength of the waste varies considerably, depending upon whether the pens are covered, the presence or absence of catch basins, practice in manure removal, frequency of washing, etc.

Slaughterhouses are establishments for the killing and dressing of meat. Little processing of the meat or of byproducts is done. Most slaughterhouses are relatively small, although some may kill several hundred animals per day.

Packinghouses are equipped to process the meat and byproducts to a much greater extent. The amount of processing varies considerably from plant to plant, resulting in wide variations in volume, strength, and chemical characteristics of effluent discharged to the sewers.

Description of Process

Slaughterhouse

The slaughterhouse or abattoir is principally a killing and dressing establishment doing little processing of byproducts. Its finished product is the fresh carcass, plus a few fresh meat byproducts such as hearts, livers, and tongues. Briefly, the process consists of stunning, sticking, and bleeding animals on the killing floor. Carcasses are trimmed, washed, and hung in cooling rooms. Livers, hearts, and kidneys are sent to the cooling rooms to be chilled before being marketed. Hides, skins, and pelts are removed from the cattle, calves, and sheep and are salted and piled until shipped to tanners or wool

processing plants. Viscera are removed and sent to rendering plants, along with feet and head bones. The feet and head bones may also be sent to glueworks. Many slaughterhouses are now equipped to do their own rendering of inedible offal into tallow, grease, tankage, and meat scraps.

Packinghouse

Packinghouse killing floor operations are, in general, carried out with more attention to recovery of salable products. Carcasses are trimmed, cleaned, and cooled much the same as in the slaughterhouse, except that the packinghouse further processes some of the meat by cooking, curing, smoking, and pickling. Some of the operations conducted, in addition to those concerning processing of meat cuts, are: manufacture of sausage and canning of meat; rendering of edible fats into lard and edible tallow; the cleaning of casings; the drying of hog hair; and the rendering of inedible fats into greases and inedible tallows.

The packinghouse is also equipped to process in varying degrees the "byproducts" which a slaughterhouse ships out as raw byproducts. Blood is collected and dried for edible and inedible uses. Tanning, wool pulling, and manufacture of glues, soaps, and fertilizers are, in general, carried on by separate plants.

Processing Plant

Processing plant operations include manufacture of smoked meats and sausage and canning of meat products. The raw materials are purchased from slaughterhouses or packinghouses in the form of carcasses, various meat cuts, and trimmings.

Raw Materials and Products

The average weight of animals slaughtered commercially in the United States in 1962, according to the Bureau of Agricultural Economics, U.S. Department of Agriculture is as follows:

Animal	Weight on hoof	Dressed weight [1]
	Pounds	*Pounds*
Cattle	1,005	574
Calves	223	[2] 125
Hogs	239	[3] 142
Sheep	97	47

[1] Not including edible organs.
[2] Hide off.
[3] Excluding lard.

The chief product, the carcass, is marketed in various cuts of fresh, smoked, cured, pickled, and canned meats, the slaughterhouse confining its production to fresh meats while the packer produces the full line of processed meats.

Byproducts of the slaughterhouse generally consist of cured hides, skins, and pelts, inedible tallows, animal feeds, and miscellaneous fresh offal (collected by specialty houses).

Packinghouse byproducts are very numerous. Some of the principal byproducts are as follows (products or uses shown in parentheses are not necessarily processed at the packinghouse):

(*a*) *Edible fats.*—Oleo stock, oil, and stearine; edible tallow; lard.

(*b*) *Inedible fats.*—Tallow; grease; neat's-foot stock.

(*c*) *Hides, skins, pelts* (pulled wool).

(*d*) *Tankage, meat scraps, and stick* (evaporated tank water).

(*e*) *Dried blood.*—(blood albumin).

(*f*) *Bone and bone products.*—Steamed bone meal; cooked bone meal; dry bone.

(*g*) *Hog hair and bristles.*

(*h*) *Horns and hoofs.*

(*i*) *Intestines.*—Sausage casings, chitterlings.

(*j*) *Glands.*

Origin of Wastewater

SLAUGHTERHOUSES

Killing floor.—Many houses save blood for sale to rendering plants or to fertilizer manufacturers. Some small houses use part of the blood to add to their tankage and sell or give away the remainder. This decreases substantially the oxygen demand

and the color of the effluent discharged to the sewer.

Paunch manure is usually segregated from the liquid wastes and disposed of separately. At some of the rural plants, it is hauled away by farmers for soil conditioning. A number of the city slaughterhouses dispose of paunch manure with garbage. The separate disposal of paunch manure reduces materially the settleable solids in the effluent entering the sewers.

Floor washes contain blood, manure, flesh, and fat particles.

Carcass dressing.—Carcass washes contain blood, flesh, and fat particles from trimming.

Rendering.—Many slaughterhouses render offal for inedible tallows and tankage. Where wet rendering is practiced, tank water remaining after grease and residue are taken off, is further processed.

Processing of tank water reduces substantially the biochemical oxygen demand and the solids content of effluent discharged to the sewer. Larger plants evaporate this tank water to produce a thick residue, called "stick," which is mixed with the tankage. Nearly all the smaller plants have installations of dry rendering and produce no tank water because any water charged into the melter is evaporated.

Inedible raw material is prepared for rendering by hashing and washing. This operation adds a considerable quantity of residue to the effluent. This residue consists of small flesh and fat particles and intestinal contents. Where the steam rendering process is used, the pressing of the residue into cakes or centrifuging produces additional tank water. This liquor is usually added to the stick evaporator feed.

Wash waters, both floor and equipment, from rendering operations contribute varying amounts of pollutional material, depending on the care exercised in handling materials and on general cleanliness.

Hide cellar.—Green hides are chuted to the cellar from the killing floor. Here they are piled flesh-side up and sprinkled with salt. A small amount of drainage from these piles, in addition to floor wash, goes to the sewer.

Hog hair removal.—Hair is loosened in a scalding tub or vat and removed by scraping. Discharge of vat waters and scrapings contribute hair, dirt, and scurf from the hog skin.

Cooling room.—Liquid wastes draining from this unit are of minor significance. Some houses use sawdust on the floor, which is swept up periodically. These sweepings may be burned, buried or disposed of in other sanitary manner.

PACKING PLANTS

Carcass dressing.—This operation is, in general, similar to that carried on in the slaughterhouse. Wash wastes are discharged into catch basins, and the grease is recovered.

Rendering.—The larger packinghouses do both edible and inedible rendering using various processes, including steam and dry rendering and low temperature rendering. Fats are hashed and washed prior to being discharged into the rendering vessels, and the wash water is discharged to lines running to a catch basin where the fats are recovered and the heavier materials are separated from the effluent. The condensate from the steam rendering produces a liquor containing various nitrogenous extracts. This liquor may be discharged to the sewers, but it is usually concentrated into what is called "stick", and the stick is mixed and dried with tankage. The residue from steam rendering is centrifuged for recovery of grease and solids. The liquors coming from the centrifuge are mixed with the tank water for conversion into stick. The bones from cattle feet are rendered in hot water to recover neat's-foot stock. The water in which the bones are cooked has some pollutional characteristics.

Hide cellar.—The wastes from the hide cellar are similar to those from a slaughterhouse but are extremely small in quantity, though high in salt content.

Hog hair removal.—In the larger plants hair removal is accomplished by a mechanical scraper. The hair is removed, washed, and sold unprocessed, or further processed by boiling in water for 8 to 10 hours with a small amount of caustic soda. The hair is removed from the cooking tank and run through pickers for breaking up the tufts of hair. It is then dried and baled for sale. The scalding vat, wash, and cook waters containing dirt, scurf, and escaped hair are discharged. Some of the smaller packing plants do not produce enough hair to justify its recovery, but dispose of it with other solid refuse.

Hair may also be hydrolyzed by steam rendering with the addition of lime. The rendered product is then dried to produce a powdered material.

Casing cleaning.—Casings are washed, cleaned of their contents and mucosa by squeezing or pressing, salted, drained, resalted, and packed for shipment. Trimmings and mucosa from the casings are rendered to recover grease and protein. The waste waters from the cleaning machines are discharged to catch basins for grease recovery.

765-014 O—65——2

Tripe room.—The tripe, or muscular part of the stomachs of cattle, is washed and scalded. The wash and scalding waters containing grease and suspended matter are discharged into catch basins. Tripe may also be produced from hog stomachs.

Sausage room.—Process consists of preparing fillings from meat and stuffing the casings. Utensil and floor washes are discharged.

Laundry.—The laundries of the large plants are of considerable size. An analysis of this waste is included with the tabulation of analyses of hog plant wastes in table 1.

Glue stocks.—The manufacture of glue is usually carried out in a separate plant. Glue is a collagenous matter extracted from heads, feet, bones, tendons, and hide trimmings by rendering them in water at different temperatures. The waste consists of wash waters used to wash the raw materials prior to extraction.

Soap.—The manufacture of soaps is confined to some of the largest houses. The average packinghouse produces the inedible tallow and grease sold to the soap manufacturers. The wastes produced from the manufacture of such greases are covered under rendering.

Fertilizers.—The production of fertilizers has lost some of its importance in the packinghouse with the advent of dry rendering which enables production of higher grade tankages which are used more for stock feed than for fertilizer. The fertilizer industry, once largely a packinghouse operation, has become more the province of the chemical industry, and packinghouse fertilizer stocks are shipped for use by fertilizer plants.

The character of the major components of the waste of a hog packinghouse is indicated in table 1.

STOCKYARDS

Stockyards appurtenant to slaughter and packing plants are ordinarily provided with catch basins and are usually floored and sometimes covered.

Wastes consist of water trough overflow, liquid excreta, and pen wash waters containing manure.

Uncovered pens are subject to flushing in rainy weather with consequent leachings from manure and carrying over of manure itself to the sewer.

The character of these wastes would be expected to vary widely, dependent on the presence or absence of catch basins, practice in manure removal, frequency of washing, etc.

PROCESSING PLANTS

The principal sources of waste occur in the processing of sausages and smoked meats. Bones, floor scraps, and other inedible trimmings are sold to renderers. Little or no wastewater originates in many of the processing operations. Principal sources during production are water used in cooking or chilling the product. The cleanup water following production contains meat and fat particles and the quantity approximates that used in processing.

TABLE 1.—*Analyses of major components of waste from hog packinghouse* [1]

	Concentration (parts per million)						
	Solids		Nitrogen		Cl as NaCl	5-day biochemical oxygen demand	pH
	Total	Suspended	Organic	NH_3			
Killing department	1, 840	220	134	6	435	825	6. 6
Blood and tank water	44, 640	3, 690	5, 400	205	6, 670	32, 000	9. 0
Scalding tub	13, 560	8, 360	1, 290	40	640	4, 600	9. 0
Hog dehairing	1, 540	560	158	10	290	650	6. 7
Hair cook water	4, 680	80	586	30	290	3, 400	----
Hair wash water	7, 680	6, 780	822	18	230	2, 200	6. 9
Meat cutting	2, 840	610	33	2. 5	1, 620	520	7. 4
Gut washer	22, 600	15, 120	643	43	360	13, 200	6. 0
Curing room	26, 480	1, 800	83	12	19, 700	2, 040	7. 3
Curing room showers	34, 100	1, 720	255	25	29, 600	460	6. 7
Cured meat wash	9, 560	920	109	17. 5	6, 200	1, 960	7. 3
Pickle	140, 000	----	2, 750	37	77, 800	18, 000	5. 6
Sausage and miscellaneous	11, 380	560	136	4	880	800	7. 3
Lard department	820	180	84	25	230	180	7. 3
Byproducts	4, 000	1, 380	186	50	1, 330	2, 200	6. 7
Laundry	18, 620	4, 120	56	5	----	1, 300	9. 6
Stockyards [2]	----	173	11	8	----	64	----

[1] Iowa Engineering Experiment Station Bulletin No. 130.

[2] From supplement D, Industrial Waste Guides, U.S. Public Health Service, 1943.

Combined Wastewater Flow and Characteristics

Quantity and characteristics of the combined wastewater from the meat industry are subject to variation depending upon the species of animals slaughtered, rendering practices, segregation of clear water, and the amount of processing carried out in the plant. Table 2 lists the losses from packinghouses per thousand pounds of live weight slaughtered, as reported by Mohlman in 1949. Similar data for nine packinghouses and three slaughterhouses are shown in table 3. Table 4 lists typical values for flow and characteristics based on present practice.

TABLE 2.—*Unit packinghouse losses* [1]

[Pounds per 1,000 pounds of live weight]

Type	BOD	Suspended solids	Nitrogen	Grease
Hogs	18. 0	12. 0	2. 67	0. 90
Do	15. 0	9. 1	1. 29	2. 30
Mixed	12. 7	4. 6	2. 02	1. 44
Hogs	13. 1	9. 8	1. 25	2. 83
Cattle	20. 8	14. 8	2. 24	. 68
Do	15. 7	14. 8	2. 01	1. 79
Do	10. 5	10. 0	1. 02	1. 00
Mixed	19. 7	9. 4	2. 59	. 60
Hogs	9. 8	7. 2	1. 46	. 27
Mixed	16. 7	15. 0	2. 18	2. 00
Cattle	10. 0	11. 0	1. 08	. 55
Mixed	14. 7	13. 2	1. 70	1. 5
Do	6. 5	6. 2	. 79	. 5
Do	19. 2	11. 2	2. 10	2. 1
Do	8. 9	10. 8	. 89	----------
Do	21. 6	21. 7	1. 82	6. 0
Average	14. 6	12. 0	1. 70	1. 63

[1] Adapted from a presentation by F. W. Mohlman at the Conference on Research of the American Meat Institute, 1949.

TABLE 3.—*Variation in unit losses between packinghouses* [1]

[Per 1,000 pounds of live weight]

Plant	Gallons of waste	Pounds of BOD	Pounds of suspended solids	Pounds of organic and ammonia nitrogen	Years of data
A	1, 300	12. 7	4. 6	2. 0	----------
B	1, 400	19. 7	9. 4	2. 6	----------
C	2, 300	16. 7	14. 9	2. 2	----------
D	3, 250	14. 7	13. 2	1. 7	----------
E	1, 300	6. 5	6. 3	. 8	----------
F	4, 350	19. 7	22. 1	2. 1	----------
G	1, 370	8. 0	10. 4	1. 0	----------
H_1	750	16. 0	20. 0	----------	1937
H_2	1, 100	10. 7	9. 1	1. 2	1949
I_1	1, 250	23. 5	16. 2	----------	1934
I_2	1, 080	11. 8	12. 0	1. 6	1950
J_2	1, 800	20. 0	11. 0	----------	----------

[1] Adapted from a presentation by Hill at the American Meat Institute's annual meeting in October 1950.

[2] Slaughtering only.

TABLE 4.—*Approximate range of flows, analyses, and waste loadings for slaughterhouses, packinghouses, and processing plants* [1]

Operation	Waste flow gallons per 1,000 pound live weight slaughtered	Typical analysis, mg/liter			Waste loading, pounds per 1,000 pound live weight slaughtered		
		Biochemical oxygen demand	Suspended solids	Grease	Biochemical oxygen demand	Suspended solids	Grease
Slaughterhouse	500–2, 000	2, 200–650	3, 000–930	1, 000–200	9. 2–10. 8	12. 5–15. 4	4. 2–3. 3
Packinghouse	750–3, 500	3, 000–400	2, 000–230	1, 000–200	18. 7–11. 7	12. 5– 6. 7	6. 3–5. 8
Processing plant	[2] 1, 000–4, 000	800–200	800–200	300–100	[2] 6. 7	[2] 6. 7	[2] 2. 5–3. 3

[1] Table prepared from data from various sources including technical literature and private correspondence.

[2] Pounds per 1,000 pound finished product.

Pollution Effects

Meat plant wastes are quite similar to domestic sewage in their composition and in their effects upon receiving bodies of water. The danger from pathogenic organisms in packinghouse or slaughterhouse wastes, however, is slight. In the absence of adequate dilution the principal deleterious effects of meat plant wastes are oxygen depletion, sludge deposits, discoloration, and general nuisance conditions.

Remedial Measures

PLANT PRACTICES

The prevention of meat and meat byproduct waste is an economic necessity. Such losses are costly because of product loss, product degradation and because of the amount of expense connected with waste treatment. Chart 1 shows the segregation of packinghouse wastewater.

REDUCTION OF SOLIDS

The first step in reducing such losses is to initiate plant procedures for minimizing the solids discharged along with the wastewater. These solids consist of fat or fatty residues that are lighter than water and fatty residues and other solids that are heavier than water. The latter are termed settleable solids. There are also some dissolved solids and nonsettleable solids (suspended solids) in the waste effluent.

SCREENING SEWER OPENINGS

Every effort possible should be made to prevent solids from being discharged with the effluent. One effective measure is to screen all sewer openings. However, the screens should be of sufficient area so as not to clog frequently, thereby requiring frequent attention to keep them open. Screening is especially necessary in killing floor operations and in the preparation of variety meats. Floors should be dry-cleaned before being washed.

SEGREGATION OF PAUNCH CONTENTS

Several municipal sewage treatment plants have been designed with effective facilities for removing paunch manure from packing plant wastewater. However where such facilities are not available, it may be necessary to remove these materials at the source.

If removal is necessary, arrangements should be made to segregate paunch and stomach contents so that they will not be discharged to the sewers. A rather effective method is to empty the paunch contents into a receiving tank from which they are pumped onto vibrating screens superimposed upon an elevated holding bin. The paunch contents are removed from this bin in trucks for disposal as refuse or as fertilizer.

Screening not only reduces the solids discharged with the effluent, but also materially lowers the 5-day BOD and grease.

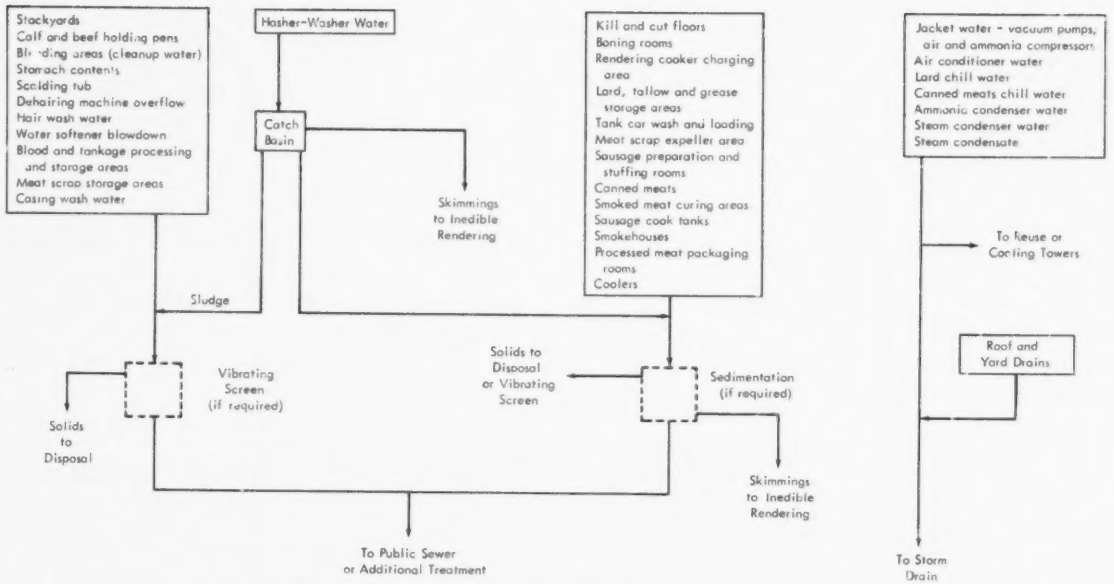


Chart I. Segregation of packinghouse wastewater

FAT RECOVERY

Catch basins (gravity separators) should be installed to receive the water from viscera hashers and washers, so as to collect the fat for rendering as close to the source of production as possible. Similar equipment should be installed for collecting the fat from gutters beneath the dressing rails on the killing floor.

Clear rendered grease such as that from a smokehouse should be caught in small sanitary catch basins which can be skimmed at frequent intervals. Collecting the grease near its source of production guarantees an improved quality for sale and eliminates its actual loss by emulsification when discharged into a large volume of effluent. This advantage should, however, be balanced against the labor cost of operating individual small basins.

Gravity separators which are not equipped with automatic skimmers and sludge collectors should be emptied once every 24 hours, at a time when there is little flow. The settlings should be cleaned out and disposed of with the paunch manure.

LIVESTOCK PENS

Livestock pens should be drycleaned, removing the manure from the pens rather than flushing it down the sewers.

BLOOD RECOVERY

All blood should be carefully collected and processed. Blood has a 5-day BOD of about 100,000 p.p.m. and a color that persists even in very high dilutions. Very small amounts of blood will raise the contaminating effect of the effluent sharply. Blood curbing and gutters should be in good repair to prevent shed blood from escaping into the dressing area where it will be sewered. Blood solids may be coagulated by sparging with live steam and then separated from the water by discharge over a vibrating screen. The water from this process still has a 5-day BOD of about 30,000 p.p.m. and a high color so it should be evaporated if possible. Drying the whole blood in a tankage drier eliminates the problem of handling the blood water separately.

WET RENDERING WASTES

When the steam rendering system is used all tank water and press water should be recovered, skimmed free of grease, and if economically possible, evaporated. Tank water has a high 5-day BOD (30,000 p.p.m.).

CASING SLIMES

Slimes from the cleaning of casings should be collected and coagulated by heat. After passage over a vibrating screen, the coagulated material may be dried and incorporated in dried tankage or dry-rendered cracklings.

TREATMENT

Meat plant wastes are amenable to biological treatment in plants of the type in common use for treatment of domestic sewage. Most meat plant wastes are discharged to a public sewer system for treatment at the municipal sewage treatment plant prior to discharge to a receiving stream. This method of handling the industrial wastes should be entirely investigated before embarking upon design of separate waste water treatment facilities. It is important that the meat plant officials discuss and reach agreement with both State water pollution control authorities and municipal sewage treatment officials before making a final decision as to the treatment and disposal of the wastewater.

Trickling filters are commonly used in municipalities which receive meat plant wastes. Typical installations are those at Cedar Rapids, Waterloo, and Fort Dodge, Iowa; Oklahoma City, Okla.; and South St. Paul, Minn. Chicago, Ill.; Indianapolis, Ind.; Milwaukee and Madison, Wis., operate activated sludge plants which receive packinghouse wastes with the domestic, commercial, and other industrial wastewaters.

The degree of pretreatment required prior to discharge of packinghouse wastes to the public sewer ranges from none in Omaha and South St. Paul to 85 percent removal of BOD in Madison, Wis. The most common pretreatment requirements include screening to remove large solids and gravity separation of grease.

Primary Treatment

Units commonly employed in primary treatment include vibrating screens, grit channels, flocculation, sedimentation, and dissolved air flotation. Johnson (*14*) showed suspended solids removal of 80 percent and total volatile solids reduction of 54 percent using a grit tank followed by flocculation and sedimentation. The use of dissolved air flotation resulted in BOD reductions of 42 percent with suspended solids and grease reduced 48 and 52 percent, respectively.

Chemical coagulation has been employed in some plants to improve removals by primary treatment. Johnson (*14*) showed addition of alum increased BOD removal 2.5 mg./l. and grease removal 1.5 mg./l. for each mg./l. of alum added. Nemerow (*22*) states grease reductions of up to 90 percent can be obtained through the use of chemicals and dissolved air flotation. High operating cost with low investment are associated with chemical treatment.

Secondary Treatment

Trickling Filters

Trickling filters containing rock sizes from 2½ to 4 inches are used in treating packinghouse wastes. Removals on a first stage trickling filter equal or exceed that of the design curve developed by the National Research Council (*20*). A plant in Rochelle, Ill., constructed in 1961 uses three-stage filters following grit removal, flocculation, and sedimentation, to achieve 95 percent BOD removal. A two-stage trickling filter plant in Madison, Wis., accomplishes 85 percent BOD removal. It is necessary to provide recirculation for the filters for periods of low flow at night and on weekends to prevent ice formation during the winter months. An hydraulic profile of a two-stage trickling filter is shown in figure 1.

Irrigation

Irrigation has been used as a method of disposal of pretreated meat plant wastes. Soil type, climate, and crop determine the area requirements for this disposal method. Seasonal loadings between April and December in Wisconsin averaged 8,000 gal./day/acre with the BOD of the irrigated wastewater as high as 480 mg./l. and suspended solids of 280 mg./l.

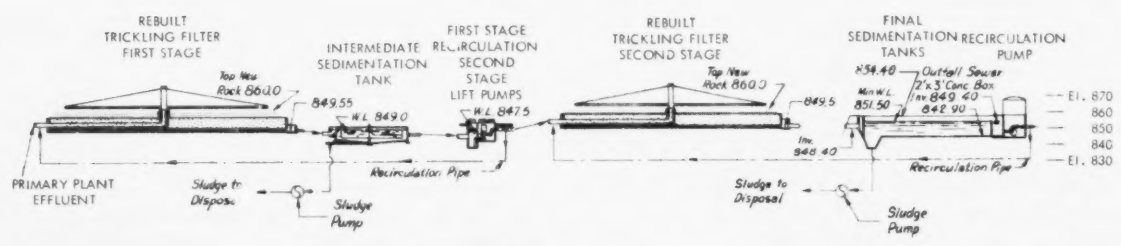


Figure 1. Trickling filter plant

The Modified Anaerobic Contact Process

Anaerobic organisms are especially suited to the destruction of organic matter in meat packing plant waste waters. They thrive best on wastes containing significant concentrations of organic solids and require temperatures of 90 to 95° F. for reasonably efficient metabolism. Packing plant wastes are usually warm (80 to 87° F.) and contain a sufficient concentration of organic matter to produce a quantity of methane gas which, when burned, will raise the waste temperature to the required level with little, if any, additional fuel required. Some other food processing wastes are also in this category, but most other industrial wastes are not.

The first full-scale modified anaerobic contact process for the treatment of meat packing plant wastes was placed in operation in December, 1959, at the Wilson & Co., Inc. plant at Albert Lea, Minn. (*19, 24, 28, 29, 30, 31*). The design was based upon pilot scale studies conducted initially by Geo. A. Hormel & Co. and later by the American Meat Institute at Austin, Minn. (*8, 25*), and upon studies on a first-stage plant built by Wilson & Co., Inc., and sized to treat half the waste water from the Albert Lea plant. Other plants of this type built since 1959 are located at Austin, Minn., to treat wastes from the Hormel plant and at Momence, Ill., to treat wastes from the Agar Packing Co. Figure 2 shows the flow plan of the completed plant at Albert Lea. The remainder of this section relates to that plant.

The full-scale plant at Albert Lea is equipped with an equalizing tank to provide storage for equalizing the flow over a full 24-hour period. Digestion takes place in two concrete digesters with tight concrete covers, into which the raw wastes, preheated to 90 to 95° F., are discharged. The detention time in the digesters is 12 to 13 hours, based upon the flow of raw wastes. In the digesters, anaerobic organisms are mixed with the wastes to digest the organic matter, yielding methane, carbon dioxide, and bacterial cells as end products. The solids in the mixed liquor (suspended solids concentration 7,000 to 12,000 mg./l) are digesting actively as the mixed liquor leaves the digesters. The mixed liquor is then discharged through vacuum degasifiers, operating at 20 inches of vacuum, to two sludge separation tanks where the sludge settles by gravity. The degasifiers remove residual gases to facilitate gravity separation.

The plant at Austin utilizes air to release the residual gases and operates at a lower BOD loading than the plant at Albert Lea. The Austin plant

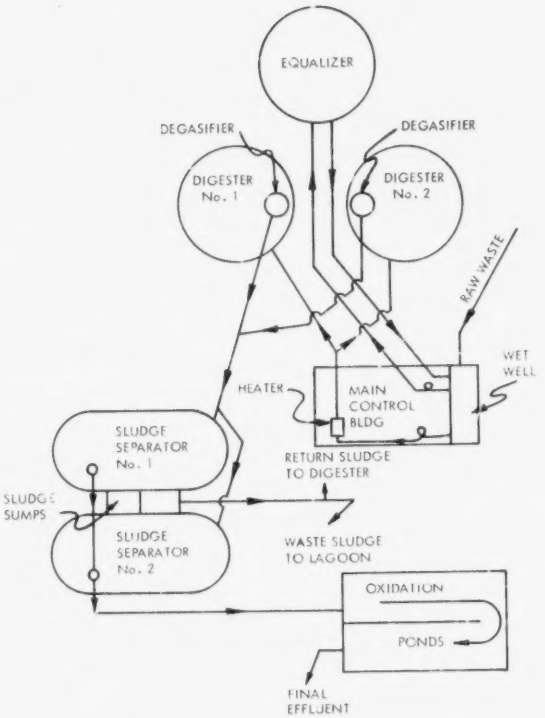


Figure 2. Flow plan, anaerobic contact process, Albert Lea, Minn.

removes 96 percent of the BOD at loadings 0.059 pounds per cubic foot per day, treating a raw waste of 1,400 mg./l. BOD.

The sludge is returned to the digesters as seed to maintain the anaerobic culture. The detention time in the separators is about 1 hour, based on total flow, including sludge circulating through the system at three volumes per volume of incoming raw waste. The surface settling rate is about 300 gallons per square foot per day, based on raw flow only. In spite of the fact that the residual gases are removed in the degasifiers, the sludge is still flocculent and must be removed with a suction-type rather than scraper-type sludge removal mechanism.

The treated effluent overflows through weir troughs to two oxidation ponds for final polishing. The ponds are 3.7 acres in area and 3 to 4 feet deep, and reduce the BOD of the anaerobic effluent 50 to 70 percent, producing an oxygenated final effluent suitable for discharge into Albert Lea Lake.

The anaerobic contact process is similar in many respects to the activated sludge process commonly used in aerobic treatment of municipal wastes and

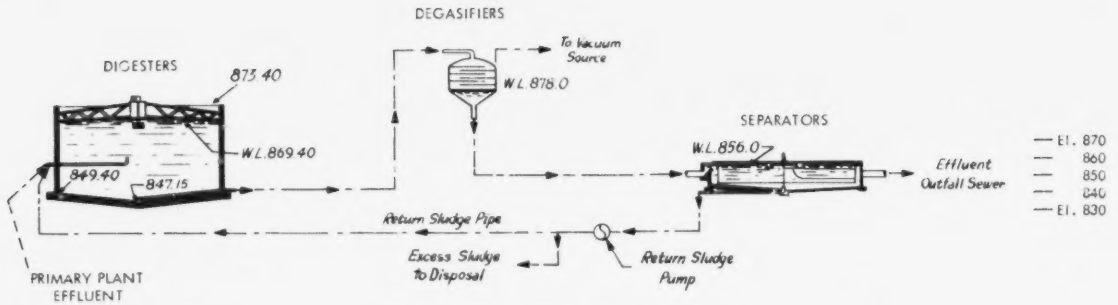


Figure 3. Anaerobic contact plant

of some industrial waste waters. As in the activated sludge process, the treatment is largely one of contact between the organisms and the nutrient in a favorable environment. After contact, the sludge, consisting of organisms and agglomerated organic matter, is separated from the treated liquid and returned to the process to serve as seed for incoming wastes. The organisms digest the organic matter in the sludge mass during the recycling and treating process. A hydraulic profile of the anaerobic contact process is shown in figure 3.

Operating data representing the average of all kill days in the year 1960 are shown in table 5. The data are based upon analyses of samples composited automatically in proportion to the flow. These results compare favorably with results obtainable in the most refined aerobic waste treatment processes.

The relative capacity of the anaerobic process in removing BOD is shown graphically in figure 4. It will be noted that the anaerobic process regularly removed 1,000 to 1,450 mg./l. of BOD, while the oxidation ponds remove a much smaller proportion of the load. However, the oxidation ponds act as shock absorbers, producing a final effluent of relatively uniform quality under a considerably wide range of loading. The first pond, which is usually anaerobic, accounts for most of the BOD removed in the pond system. (See table 6.)

*Stabilization Ponds for Meat Packing Wastes**

DEVELOPMENT IN MEAT INDUSTRY

Since most meat processing plants are located in urban areas where land is relatively expensive, and since meat packing wastes are amenable to treatment in conventional aerobic systems, the adoption of stabilization basins by this industry has been somewhat slow. However, the popularity of stabilization basins, both for complete and partial treatment of meat packing wastewaters, has increased in recent years, partly stimulated by developments in the municipal field and partly by research in anaerobic fermentation. The ponds may be used as tertiary treatment following conventional aerobic systems or anaerobic contact systems; or they may be used as

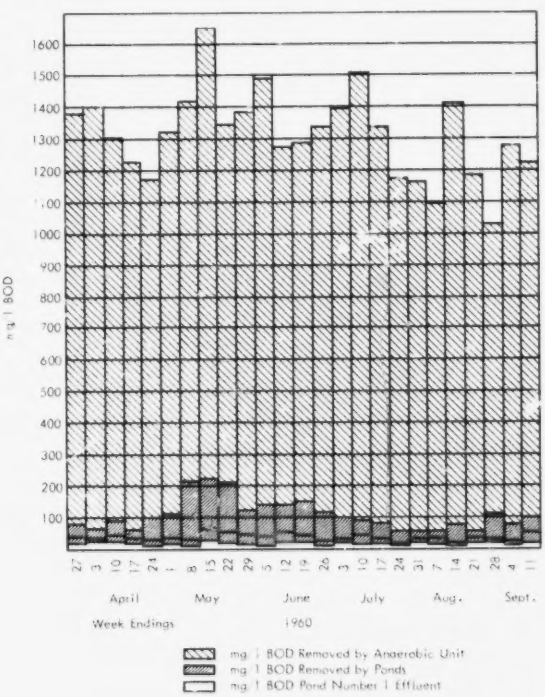


Figure 4. Weekly average BOD data

*Portions of this section are taken from "Stabilization Ponds for Meat Packing Wastes" by A. J. Steffen and are reprinted with permission from Journal Water Pollution Control Federation, vol. 35, No. 4, p. 440 (April 1963), Washington, D.C.

TABLE 5.—*Average operating data (all killing days in 1960)*

	Raw waste		Anaerobic process effluent		Pond effluent	Loss in ponds
Flow, gallons	1,410,000		1,410,000		772,000	638,000
	Raw waste		Anaerobic process effluent		Plant effluent corrected for seepage	
	mg./l.	Pounds	mg./l.	Pounds	mg./l.	Pounds
BOD	1, 381	16, 220	129	1, 517	26	304
Suspended solids	998	11, 610	198	2, 325	23	268
Suspended volatile solids	822	10, 370	153	1, 800	20	232
Total solids	2, 100	36, 500	2, 080	24, 450	1, 076	12, 500
Total solids—water supply	560	6, 500	560	6, 500	560	6, 500
Total solids after deducting TS in water supply	2, 540	30, 000	1, 520	17, 950	516	6, 000
Total volatile solids	1, 700	19, 980	800	9, 400	367	4, 310
Total volatile solids in water supply	300	3, 520	300	3, 529	300	3, 520
Total volatile solids after deducting TVS in water supply	1, 400	16, 460	500	5, 880	67	790

secondary treatment, either as two-stage anaerobic-aerobic systems or single-stage aerobic basins, following primary grease and solids separation; or they may be used as complete treatment following conventional grease recovery.

With so many different types of systems in use, any attempt at generalization is difficult and uncertain. Variations in the character of the raw waste, in the degree of pretreatment, in the meat processing operations, in waste conservation practices, in climatic conditions, and in subsoil characteristics will all affect the design. Some basins are anaerobic by design, others by accident. Reported loadings in conventional aerobic stabilization ponds range from 50 lb./day/acre (*3*) treating raw meat packing wastes in South Dakota, to 214 lb./day/acre for relatively dilute processing wastes in Delaware (BOD 175 mg./l.) following primary clarification and equalization of flow (*1*). The latter system consists of two ponds in parallel, 18 inches deep, with a detention period of 2.89 days and BOD reductions ranging from 96 percent in the summer months to 70 percent in the winter months. The extreme difference in loading in these two instances illustrates the beneficial effects of primary clarification.

OTHER EXAMPLES

Because meat packing wastes are warm (80 to 87° F.) and contain significant concentrations of highly nutritive suspended organic solids, they are especially responsive to anaerobic fermentation processes. The industry has found that raw wastes can be treated effectively and economically in a combination of anaerobic and aerobic ponds. The first system of this type, designed from laboratory and pilot scale data, is operating at the Swift & Co. plant at Moultrie, Ga. (*26*), treating a meat packing waste in an anaerobic lagoon 14 feet deep and 1.4 acres in surface area, followed by an aerobic lagoon with a total area of 19.2 acres and a depth of 3 feet.

TABLE 6—*Operating data for oxidation ponds and treatment plant*

	Percent Removal			Digester loading lbs./cu. ft./day
	Through anaerobic unit	Through ponds	Through entire plant	
BOD	90. 8	79. 8	98. 2	0. 156
Suspended solids	80. 2	88. 4	97. 6	0. 112
Suspended volatile solids	82. 8	86. 8	97. 8	----------

The detention time is 6 days in the anaerobic pond and 19 days in the aerobic pond. The BOD loading is about 0.014 lb./day/cu. ft. in the anaerobic stage, and 50 lbs./day/acre in the aerobic stage, with an overall BOD loading of 325 lbs./day/acre. Sludge is recirculated in the anaerobic lagoon and effluent is recirculated in the aerobic lagoon. The BOD of the raw waste averaged 1,100 mg./l., and the effluent averaged 67 mg./l. over a 4-year period. The second system installed by the same packer (*26*) at Wilson, N.C., consists of an anaerobic lagoon 17 feet deep with 3.5 days detention, followed by trickling filter treatment in the municipal plant.

A pond system treating meatpacking wastes in New Zealand (*34*) consists of anaerobic ponds with 1½ days detention, followed by an aerobic pond with 5 to 7 days detention, and yields 97 percent BOD reduction. The anaerobic ponds are recirculated at 2 to 1, and the aerobic ponds at 0.6 to 1. The BOD loading in the anaerobic system is 0.012 lb./day/cu. ft.

A system in Virginia (*35*) consisting of primary clarification followed by two ¼-acre ponds, each 8 feet deep, is loaded at a rate of 1,360 lbs./ of BOD/ day/acre. The average BOD of the wastes entering the first pond, based on a year of record, was 1,135 mg./l.; the effluent of the first pond was 233 mg./l., and the final effluent was 82 mg./l. The first pond is normally anaerboic, and the second is partly aerobic with some algal growths. The BOD loading on the second pond is 280 lbs./day/acre. The good results, in spite of the heavy loading on these ponds, indicate the benefits from presedimentation and anaerobic fermentation.

A system in Idaho (*36*), entirely anaerboic, consists of 3 ponds in series with an area of 2.8 acres, 8 feet deep, treating a raw BOD of 1,430 mg./l., and discharging an effluent of 490 mg./l. at a BOD loading of 520 lbs./day/acre. The results of this plant are adversely affected by the discharge of paunch manure and other solids to the pond. However, the high capacity of the anaerobic ponds for BOD removal is evident.

Twelve small rural abattoirs in Louisiana are successfully treating their entire wastes (*4*) in three-stage pond systems, each consisting of an anaerobic pond, a transitional pond, and an aerobic pond. The entire paunch manure and grease are discharged with the raw wastes to provide a mat on the anaerobic pond. Difficulties in the anaerobic stage of treatment have been experienced wherever this mat did not develop. Based upon an estimated BOD of 2,000 mg./l. and a flow of 800 gallons per 1,000 pounds live weight kill, the anaerobic ponds were designed at 30,000 pounds live weight kill/day/acre-foot, the transitional ponds at 150,000 pounds, and the aerobic ponds at 75,000 pounds. The anaerobic pond is generally about 15 feet deep, and the transition and aerobic ponds about 4 feet deep. There is no recirculation or supplemental heating in the systems. An average of composite samples taken at three plants gave a raw BOD of 2,270 mg./l., anaerobic effluent 183 mg./l., transition pond effluent 85 mg./l., and aerobic pond effluent 56 mg./l., with an overall BOD removal of 98.5 percent.

STABILIZATION PONDS USED WITH ANAEROBIC TREATMENT

Aerobic stabilization lagoons treat the effluent of an anaerobic contact system receiving meat packing wastes at the Wilson & Co., Inc., plant at Albert Lea, Minn. (*31*). As shown in photograph (p. VI) and figure 2, page 9, the two ponds at this plant, operating in series, are 3.7 acres in area and 3 to 4 feet deep. Here, also, removal of suspended solids and much of the BOD permits heavy loading in the ponds. The average BOD loading during an entire year of record was 410 lbs./day/acre, receiving a waste averaging 129 mg./l. BOD and 198 mg./l. suspended solids.

Of an average of 1.41 million gallons per day of raw wastes, about 45 percent was lost in seepage and evaporation from the ponds. Loss at the beginning of the year was 65 percent and at the end about 31 percent, indicating gradual sealing of the bottom of the ponds. The ponds produce an effluent BOD less than 30 mg./l., after correction for seepage (also see "The Modified Anaerobic Contact Process"). Less than half of the total solids and only 18 percent of the total volatile solids remaining in the effluent represent solids added to the plant water in converting it to used water.

Summary

Experience in the use of stabilization basins for the treatment of meatpacking wastes falls into the following general categories:

1. Complete treatment consisting of anaerobic basins 8 to 17 feet deep, loaded at 0.011 to 0.015 lb. BOD/day/cu. ft., followed by conventional aerobic stabilization lagoons loaded at 50 to 280 lbs. BOD/day/acre. Separate recirculation of both stages improves treatment. Since meatpacking wastes are warm (80 to 87° F.) and are excellent nutrients, they are well suited to anaerobic treatment.

2. Complete treatment by conventional aerobic stabilization lagoons is limited to lower BOD loadings, possibly in the range of 50 lbs./day/acre, depending on the degree of treatment desired.

3. Secondary treatment by aerobic stabilization lagoons, following equalization of flow and primary clarification, permits BOD loading in excess of 200 lbs./day/acre, with BOD removal ranging from 96 percent in the summer to 70 percent in the winter at temperatures as low as 36° F.

4 Tertiary treatment, following the anaerobic contact process and utilizing conventional aerobic stabilization lagoons, will successfully treat the effluent of an anaerobic process containing an average BOD of 129 mg./1. at an average loading of 410 lbs./day/acre, and will produce an aerobic effluent of less than 30 mg./1. BOD.

Bibliography

1. Anderson, J. S., and Kaplovsky, A. J., "Oxidation Pond Studies on Eviscerating Wastes from Poultry Establishments." Proceedings of the 16th Industrial Waste Conference, Purdue University Extension Service, 109, 8 (1962).
2. Bragstad, R. E., "Industrial Wastes at Sioux Falls, South Dakota." Proceedings of the First Industrial Waste Conference, 22, Purdue University (1944).
3. Carl, C. E., and Kalda, D. C., "Waste Stabilization Ponds in South Dakota." Proceedings of the Symposium on Waste Stabilization Lagoons, Public Health Service (1960).
4. Coerver, J. F., "Louisiana Practice and Experience with Anaerobic-Aerobic Pond Systems for Treating Packinghouse Wastes." Journal Water Pollution Control Federation, 36, 5 (1964).
5. Cropsey, W. H., and Larson, K. D., "Sewage Treatment at South St. Paul, Minnesota." Sewage Works Journal, 19, 1051 (1947).
6. Dawson, F. M., and Kalinske, A. A., "Symposium on Grease Removal—Design and Operation of Grease Interceptors." Sewage Works Journal, 16, 482 (1944).
7. Eldridge, E. F., "Industrial Waste Treatment Processes and Plant Design." Michigan Engineering Experiment Station Bulletin No. 82 (1938).
8. Fullen, W. J., "Studies in the Anaerobic Digestion of Packinghouse Waste." Proceedings of the Third Conference on Research, American Meat Institute, p. 63 (1950).
9. Gold, D. D., "Bibliography and Abstracts of Articles Relating to Slaughterhouses and Packing House Wastes." Bulletin No. 14, Engineering Experiment Station, University of Tennessee. (May, 1951).
10. Gold, D. D., "Summary of Treatment Methods for Slaughter House and Packing House Wastes." Bulletin No. 17, Engineering Experiment Station, University of Tennessee. (May, 1953).
11. Gurnham, C. F., ed., "Industrial Wastewater Control," Academic Press, Inc., New York, (1964).
12. Howson, L. R., "Packing House Waste Treatment," (West Fargo, N. Dak.). Water Works and Sewerage, 87, 217 (1940).
13. Huppert, J., "Chemical Treatment Plant for Packing House Wastes." Sewage Works Engineering, 20, 437 (1949).
14. Johnson, A. S., "Newer Aspects in Treatment of Packing House and Feedlot Wastes," Transactions, 14th Conference on Sanitary Engineering, University of Kansas, Lawrence, (1964).
15. Klassen, C. W., and Hasfurther, W. A., "Treatment of Wastes from Small Packing Houses." Sewage Works Engineering, 20, 136 (1949).
16. LeBosquet, J., Jr., and Symons, G. E., "Buffalo Sewer Authority," unpublished data.
17. Mohlman, F. W., "The Growing Importance of

Industrial Waste Disposal." Water Works and Sewerage, 87, 93 (1940).
18. National Provisioner, Inc., "Annual Meeting Packers Guide." 1945, pp. 54, 94, 96; 1946, pp. 63, 101, 84; 1947, pp. 69, 90.
19. National Provisioner, Inc.. "Unique Wilson Waste Plant Cuts BOD to Low Level." July 16, 1960, 143, No. 3, 26.
20. National Research Council, "Sewage Treatment at Military Installations." Sewage Works Journal, 18, 5, 971 (May, 1946).
21. Nelson, D. H., "Meat Packing Wastes and Their Pretreatment." Sewage Works Engineering, 20, 382 (1949).
22. Nemerow, N. L., "Theories and Practices of Industrial Waste Treatment." Addison-Wesley Publishing Co., Inc., Reading, Mass. (1963).
23. Ohio River Pollution Survey files.
24. Pietraszek, Gregory, "New Era in Treatment of Packinghouse Wastes Opens with Successful Start of Anaerobic Unit at Wilson Plant." National Provisioner, 137, 2, 18 (July 13, 1957).
25. Schroepfer, G. J., Fullen, W. J., Johnson, A. S., Ziemke, N. R., and Anderson, J. J., "The Anaerobic Contact Process as Applied to Packinghouse Wastes." Sewage and Industrial Wastes, 27, 4, 460 (April 1955).
26. Sollo, F. W., "Pond Treatment of Meat Packing Plant Wastes." Proceedings of the 15th Industrial Waste Conference, Purdue University Extension Service, 106, 386 (1961).
27. Steffen, A. J., "What to do about Paunch Wastes." Proceedings of the Third Waste Conference; 268 Purdue University (1947).
28. Steffen, A. J., "Full-Scale Modified Digestion of Meat Packing Wastes." Sewage and Industrial Wastes, 27, 12, 1364 (December, 1955).
29. Steffen, A. J., "Treatment of Packinghouse Wastes by Anaerobic Digestion." Chapters 1–12, "Biological Treatment of Sewage and Industrial Wastes," Volume 2. "Anaerobic Digestion and Solids-Liquid Separation," edited by McCabe, Joseph, and Eckenfelder, W. W. (Reinhold Pub! 1958).
30. Steffen, A. J., "The Modified Anaerobic Contact Process." Proceedings of the 13th Research Conference, American Meat Institute Foundation, University of Chicago (March, 1961).
31. Steffen, A. J., and Bedker, M., "Operation on Full Scale Anaerobic Contact Treatment Plant For Meat Packing Wastes." Proceedings of the 16th Industrial Waste Conference, Purdue University Extension Service, 109, 423 (1962).
32. U.S. Public Health Service, unpublished data.
33. West Virginia Water Commission, "Slaughter House Waste Treatment Guide." Charleston, W. Va. (1946).
34. Data supplied by owner (1961).
35. Data supplied by owner and Virginia State Water Control Board (1962).
36. Data supplied by owner (1962).

U.S. GOVERNMENT PRINTING OFFICE: 1965 O—785—014